

MINNESOTA,

FROM THE STANDPOINT OF

PUBLIC HEALTH.

*COMPILED BY THE SECRETARY OF THE STATE BOARD OF
HEALTH, AS SUPERINTENDENT OF MINNESOTA
SANITARY EXHIBIT AT THE EXPOSITION
IN NEW ORLEANS, IN 1885.*

SAINT PAUL :
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PREFACE.

This little pamphlet is prepared as a part of the Sanitary Exhibit of Minnesota at New Orleans, at the request of the State Commission. It offers a sketch of the State from the standpoint of Public Health, and puts in convenient and reliable shape many facts hitherto scattered and not readily available. The contents may be classed as—

- I. An Inventory of Minnesota's share of the great and essential natural elements of healthfulness in Climate; Water; Soil and Topography.
- II. The Character, distribution and physical traits of her Population. •
- III. Her Health Code and Sanitary Organizations for the removal or control of nuisance and disease.
- IV. Her Vital Statistics, as indicating the leading causes of sickness and mortality and the influence of sanitary work thereon.

Nothing but an outline has been attempted or is practicable, but that has been drawn in strict accord with facts—chiefly scientific facts—the results of steady and persistent scientific work.

Particular attention is invited to the "Health Code" of the State which for unity, completeness and simplicity of organization, facility of use, and economy of administration is believed to be a great advance in American Public Hygiene.

It proves that no other State is more thoroughly alive to the advantage of such work or more ready to command and furnish, the means for its organization and execution, than Minnesota.

C. N. H.

GEOGRAPHY, TOPOGRAPHY, WATER SUPPLY, SOIL AND CLIMATE.

The state occupies the summit divide of the waters of the United States. The height of the main divide west and southwest of Itasca Lake is 1,600 to 1,700 feet above the sea, and the average elevation of the entire State about 1,275 feet. The border of Lake Superior is the lowest, 602 feet, and the Mississippi River at the southeast boundary of the State, in Houston county, 620 feet. The N. W. corner at St. Vincent is 800 ft.; the S. W. corner 1,443 ft. above tide water, and the central portion ranges from 1,000 to 1,750 feet. Hence, the streams of the State draining 84,286.53 square miles are characterized by their tortuous courses and are generally navigable.

The water area is greater than that of any other State or territory, in the Union, (5,637.53 square miles, excluding Lake Superior,) "an average of one square mile of water to every fifteen of land in the entire state." This immense water supply leaves our territory by seven routes; on the north by the Rainy Lake river, Vermillion and other streams, into the Lake of the Woods; northwest into the Red River and then into Lake Winnipeg; west from Lake Traverse into the Red River, and from Big Stone Lake into the Minnesota river and across the State into the Mississippi. The southwest corner of the State delivers its waters into the Minnesota and its tributaries. On the south side the drainage by the Rock, Des Moines, and Cedar rivers, and their tributaries through Iowa into the Mississippi. On the east, into Lake Superior, the St. Croix and Mississippi. The largest drainage is by the Mississippi and its tributaries, about 45,566 square miles. The upper Mississippi drains the great timber

belt, and the Minnesota the southern prairie portions of the State.

The Mississippi runs on the drift to the Falls of St. Anthony, and thence both it and its tributaries through rocky valleys to the southeast limit of the State.

The Red River Valley region is bounded on the east by rising land, the river being the western boundary of the State; on the south by the great divide, and terminates at St. Vincent, 800 feet above the sea. This fertile plain is flat, and was a dreary waste before settlement and tree planting, but is now the garden of wheat culture, and rapidly filling up with a thrifty and busy population. The Red river drains 15,107 square miles and is navigable to Moorhead, on the Northern Pacific Railroad. On the south side of the State the Des Moines drains 1,940 square miles of prairie land, into the Mississippi, (through Iowa); the Rock river, 1,702 of southwest corner of State, into the Missouri. The Cedar river drains 1,098 square miles into the Mississippi through Iowa.

Of the land in the State, 31,800 square miles is prairie, 52,200 is forest (including in each the water area of each.)

The timber land embraces all that portion of the State east of the Red River region and of the north side of the Minnesota River region. The prairie region from a beginning 50 miles wide, east of the Red river at St. Vincent, gradually extends in breadth till on the southern side it occupies the whole territory. Roughly stated, the two sections are divided by a line running from 50 miles east of Red river, on the Canadian boundary, to the Mississippi River, at the southeast angle of the State. But all varieties of soil may be found from the broad and rolling prairie of the southwest part of the State to the mountainous

region of the northeast, 2,200 feet above tide water. Every region is now thoroughly accessible by water and rail, and the climate corresponds in variety.

The forests are chiefly of pine, tamarac and spruce in the northern portion. In the southern, the hard and soft maple, black walnut, elm, bass, ash, poplar and cottonwood.

THE WATER SUPPLY.

It may be divided into four great classes:

1. The waters of the northeast section.
2. The waters of Red River group.
3. The waters of the Minnesota and Mississippi valleys.
4. The waters of the high prairie region.

Each contains, of course, river, spring, well, and artesian well waters. Their difference will appear upon comparison of data taken from the records of the laboratory of the State Board of Health, which will be found in appendix A. Similar data have been taken from the reports of the State Boards of Health of Massachusetts and New York which enable a comparison of the various water supplies of those States with that of Minnesota.

The public water supply of the towns and cities is taken at St. Paul from Lake Phalen and adjacent lakes; at Brainerd, Minneapolis, Red Wing and Winona, from the Mississippi River; at Duluth, from Lake Superior; at Moorhead and Fergus Falls, from the Red River; at Stillwater, from Lake McKusick; at Faribault, from well tapping deep springs.

The artesian wells which are increasing in number, have not yet been used in public water supply. Those in the Red River Valley, so far as examined, contain a moderate

excess of chlorine, and of the salts of soda and magnesia, not sufficient, however, to prevent their domestic use, and it is believed that experience in sinking them will diminish this proportion by finding better strata for the supply. There is a marked difference in this respect, according to depth. The whole subject, however, still awaits further development.

Of course, as in all new countries, the chief domestic supply is from springs, rivers and wells.

The first two are as yet unpolluted, but the last, in our larger towns have begun to show the influence of out-houses, cess pools, and surface filth. The danger to health from this source is greatly diminished by the general habit of referring samples of suspected water with full description of the source, to the laboratory of the State Board of Health for analysis and opinion. In this way the use of many wells has already been forbidden by the local Boards of Health. An encouraging feature of this question worthy of note, is the increasing number of requests for such analysis and opinion from heads of families from all parts of the State, country districts, villages and cities. The recent legislation making the State Board of Health the guardian of the public water supply was the direct result of a popular appreciation of its necessity.

Maps, diagrams, photographs and drawings of the water and sewer systems of the cities of St. Paul, Minneapolis, Stillwater and Red Wing have been promised, and it is expected that they will be on exhibition on "Minnesota Day," when this pamphlet will be ready for distribution.

The descriptions of the same, furnished by the several boards, will be found in appendix B.

CLIMATE.

"Observations extending over a term of 35 years record a mean temperature in spring and autumn of 45 deg. F.; in summer, 70 deg. F., and in winter of 16 deg. F.

For nine years ending 1883, the following are the means by records (omitting fractions):

Mean Winter Temperature,	-	-	19 deg. F.
" Spring	"	-	40 deg. F.
" Summer	"	-	69 deg. F.
" Autumn	"	-	45 deg. F.
Range for Winter and Spring Months, greatest,			75 deg.
" " " " frequent,			50 deg.
" " " " least,			41 deg.

Range for summer months never exceeds 40 deg.

Mean temperature of all Minnesota, below 47 deg. latitude, except east half of counties along Iowa line, 40 deg. F.

This (40 deg.) is also the summer mean of the Red River Valley as far north as Pembina.

Rest of State, extending to Rainy river, has mean temperature, 36 deg. F."

This following table gives mean annual temperature for nine years.

* AVERAGES OF YEARS '75 TO '84 INCLUSIVE.				Temper- ature.	Humid- ity.
1.	1876, November	'75 to November,	'76.....	42.50	68.06
2.	1877, "	'76 "	'77.....	43.73	66.67
3.	1878, "	'77 "	'78.....	48.25	69.81
4.	1879, "	'78 "	'79.....	43.54	67.66
5.	1880, "	'79 "	'80.....	45.90	67.95
6.	1881, "	'80 "	'81.....	42.02	68.51
7.	1882, "	'81 "	'82.....	45.14	68.38
8.	1883, "	'82 "	'83.....	39.96	71.54
1884, January '84 to January '85, (for St. Paul).....				43.78	72.76
Average for 9 years.....				43.95	69.03
Average for 14 years at St. Paul.....				45.2	69.1

*Stations of observation, in number 8 to 12 at different times, included the extremes of the State, Duluth in N. E., Winona in S. E., Moorhead in N. W., and St. Peter in S. W., and several intermediate stations. Taken from the State Board of Health Meteorological Reports.

Rainfall of different parts of State are as follows;

Big Stone Region,	-	-	Average annual, 28 inches
Southeast Portion,	-	-	" " 40 "
Head of Mississippi, -	-	-	" " 24 "
Near Pembina,	-	-	" " 20 "

For 9 years ending 1883, melted snow and rainfall by seasons is:

Winter Months Ranged	-	-	1.64 to 4.69 inches.
Spring " " -	-	-	6 " 9.76 "
Summer " " -	-	-	9.12 " 13.89 "
Autumn " " -	-	-	4.56 " 7.80 "

For St. Paul during 1884, total rain-

fall (including snow) was	-	-	26.11 "
Average for 14 years,	-	-	28.98 " "

SANITARY LEGISLATION AND ORGANIZATIONS.

In common with other Western States, Minnesota began this kind of legislation while yet a territory, by a general law conferring very arbitrary, but ill-defined, powers upon local authorities, all of whom were made local Boards of Health. Afterwards, except in townships, these boards were made separate from, but appointed by local authorities. Then their number, mode of appointment, term of service and functions, were varied by the different wording of charters and special laws. Afterwards special legislation was had as to particular diseases of animals and of men, outside the jurisdiction of the Local Boards of Health. Soon laws relating to matters of Public Health, made in this way, with no definite general purpose or system, occasioned much confusion and difficulty, in the attempt to control epidemics by co-operation between local Boards of Health, or even, in some instances, to know just what was the power of such boards. Meantime the public interest in sanitation, as an agent of health and safety, had

increased rapidly all over the country, and the necessity for better local organization and for some form of State organization as well, became so evident that Massachusetts led the advance by the organization of a State Board of Health. California followed, and in 1872, upon the petition of the State Medical Society, the legislature of Minnesota enacted the Massachusetts law, and in March of that year, the State Board of Health was organized and began its work, which has gone on continuously since.

Progress in the codification of sanitary law has been intentionally slow, because popular and even professional opinion in 1872, and for several years after, had not yet demanded it. One of the first steps taken was to give regular instruction in hygiene in the University. The secretary of the State Board of Health was elected Professor of Public Health and has taught regularly ever since. He has addressed teachers' institutes and obtained an examination in hygiene and the health laws of the State as prerequisite to the certificate of the teachers in the common schools.

Popular sanitary councils have been held in various parts of the State for several years, awakening marked popular interest in the subject of local hygiene, and in voluntary organizations for sanitary work.

In 1875 the State Board secured legislation for the care of inebriates, and though the hospital built therefor has been converted into one for the insane, provision is there made for the special care of inebriates in apartments specially arranged for them.

In 1875 the Board secured an act making the standard for kerosene oil in the state 150 deg. F. flash. That standard has since been reduced to 110 deg. F. despite the opposition of the Board, who, having the regulation of the mode of testing, will continue the endeavor to improve the quality

of kerosene, not only as to flash, but as to the amount of heavy oils permitted to be retained. A series of studies of kerosene, with a view to maintaining a high standard of purity, has been made in the laboratory of the Board, the first report in 1876, the last in 1885, and the work will be continued. SPECIAL STUDIES OF THE INFLUENCE OF OUR CLIMATE UPON PULMONARY DISEASES; OF THE CAUSES OF INFANT MORTALITY; OF THE RELATIONS OF SCHOLASTIC METHODS TO THE HEALTH OF PUPILS IN THE PUBLIC SCHOOLS, and of a variety of other practical questions growing out of the work of the Board, have been made and published.

In 1879 this Board proposed a NATIONAL ORGANIZATION OF STATE BOARDS OF HEALTH FOR MUTUAL STUDY AND CO-OPERATION, particularly in the control of epidemics. Again, in a meeting of State Boards in Washington, in spring of 1884, it secured such an organization in skeleton form. Later in the year at St. Louis, at the conference of State Boards, it proposed a formal plan for the organization of that body, and will continue to urge its adoption till a part or all of the State Boards of Health are so united; as the next step necessary in sanitary organization in the United States.

CHEMICAL LABORATORY.—This Board has maintained a chemical laboratory for more than ten years. The sanitary analysis of the water supply of the State has gone on regularly the whole of that time, chiefly of samples of suspected water sent for opinion. A portion of the results are given under the appropriate head in this paper.

In 1878 the Board asked and obtained a codification of the laws relating to infectious diseases of men, and establishing a thorough co-operation and mutual responsibility between State and Local Boards of Health for their suppression or control. This code is based largely upon the general Health Law of England, adjusted to American

ways, and combining the results of the American experience.

In January, 1885, during the session of the legislature, the State Board of Health, for the first time in this country, called a conference of health officers and other representatives of Local Boards, at St. Paul, which was largely attended. After a full and thorough discussion of the matter this conference agreed with the State Board as to the necessity for further legislation, and united in asking

That Local Health Board organization, term of service and functions be unified; by giving to all the same membership, of at least three, one of whom should be a physician and health officer; that members should be elected, one for three, one for two, and one for one year, and thereafter one every year, and that greater independence and liberty of action should be accorded to such Boards, with more intimate relations to the State Board: and lastly, that their expenses for control of infectious disease, should be paid by counties, and in case of townships who have no general fund, should be promptly met from the county treasury. An act to that effect is now law in Minnesota. As a consequence, after the first Monday in April, 1885, there will be in active and continuous existence over 1,100 township and nearly 100 village and city Boards of Health, in the State.

It was further asked that the LOCAL AND STATE BOARDS OF HEALTH BE GIVEN CHARGE OF INFECTIOUS DISEASES OF DOMESTIC ANIMALS, with authority to enforce the necessary measures for the control of such diseases, by the employment of competent veterinary surgeons, and the quarantine or destruction of suspected or infected animals. Compensation may be allowed in the judgment of said Boards for animals destroyed, except in the case of Glanders or Farcy.

The State Board of Health is given the powers of justices

of the peace in making such investigations as are necessary for this work.

A bill containing the general features of the existing Massachusetts law, and appropriating \$3,000.00 for the expenses of the state in enforcing the same was passed and is now a law of Minnesota.

On the same petition the State Board of Health was given the GENERAL SUPERVISION OF ALL SPRINGS, WELLS, PONDS, LAKES and STREAMS, used as source of public water supply, with power to enforce the necessary regulations for the purity of the same; and it is made the duty of the judges of district courts to issue an injunction to enforce the orders of said State Board of Health. Provision is made for appeal from the order of the Board to the district court, with bond in the sum of not less than \$2,000.00, conditioned for the prosecution of such appeal to judgment, and for the payment of the costs and expenses thereof. Provision is also made for such reports from Water Boards or Commissions as to their respective water supply, as the State Board of Health may require, and suitable penalties are attached to failure to comply with the law.

Under an ACT TO REGULATE OFFENSIVE TRADES AND EMPLOYMENTS, Local and State Boards of Health are empowered to regulate the exercise of any trade or employments which is "a nuisance or hurtful to the inhabitants or dangerous to the public Health, or the exercise of which is attended by noisome or injurious odors, or is otherwise injurious to the estates of such inhabitants, or may prohibit such trade or employment, or forbid their exercise within the limits of the town, or particular locality thereof."

Penalties are attached; appeal may be taken from the order of such Boards to the district court within five days, on filing bond of not less than \$500, in other respects as provided in regard to water supply.

The State Board of Health, on appeal, may give a hearing in cases of complaint under this act, and during the pendency of the appeal the trade or employment complained of, may not be exercised under penalty of its dismissal, and the district court may issue an injunction or other proper writ to enforce the orders of the State Board of Health under this act. This act does not impair any other remedy which may exist in case of nuisance.

The APPROPRIATION for the use of the State Board of Health for its ordinary work is \$5,000 per annum.

CONTINGENT FUND FOR CHOLERA.

Fifteen thousand dollars is appropriated for the expenses which may be incurred by the State Board of Health in any emergency which may arise from cholera in the State.

POWERS OF LOCAL BOARDS OF HEALTH IN THE CONTROL OF INFECTIOUS DISEASES.

In addition to the powers specified above of Local Boards of Health, the following are noteworthy :

I. WRITTEN NOTIFICATION OF THE EXISTENCE OF CONTAGIOUS OR INFECTIOUS DISEASE IS OBLIGATORY on the part of physicians and householders, giving name, residence and disease.

II. They may provide hospitals for infectious diseases and control their administration; may seclude persons exposed to or infected with such disease; may provide for the transportation of the sick of such disease, and for the disinfection of persons and things, or may destroy infected things and allow compensation therefor.

III. They must care for persons non-residents suffering from such diseases, collecting the expense of such cases of the counties in which they have legal resi-

dence, or from the State, if not citizens of the State. This on approval of the State Board of Health.

Provision is made in the organization of the College of Medicine of the University, for a practical knowledge of hygiene on the part of the applicants for the degrees of M. B. or M. D., and for a special examination for the degree of "Licentiate in Sanitary Science," the possession of which it is hoped will be, in the near future, required of applicants for the position of Health officer.

This summary of the sanitary legislation and organization of Minnesota would be incomplete and unjust if it did not include the other fact, that they are the expression of the sentiment and feeling of her people. All classes, men and women, have, as opportunity offered, expressed their wishes in the most effective manner, in Sanitary Conferences, in the newspapers and through successive Legislatures.

A tribute of thanks is due to Ex-Governors Horace Austin, C. K. Davis, and John A. Pillsbury, and to the present incumbent of the office, Hon. Lucius F. Hubbard, during whose administration the greatest advance has been made. Our Governors have given to matters of Public Health a consideration and support which has been the outgrowth of a careful study of the subject as a matter of State policy and substantial advantage, and have afforded to the State Board of Health the assistance of their knowledge of men, and practical business methods, without which much which has been accomplished would have failed.

The present satisfactory state of sanitary matters in Minnesota is therefore the resultant of all the forces which go to make progress possible in a great commonwealth, and finds therein a firmer foundation than could, in any other way, be afforded for continuous and successful work.

This work has been the prevention or control of infectious and contagious diseases, and the diminution of the frequency and severity of other preventable disease. It has been done, not merely by special measures, as quarantine, disinfection, vaccination, etc., but by the constant effort to make the REMOVAL OF CAUSES OF DISEASE MORE AND MORE THE HABIT OF COMMUNITIES, AS OF INDIVIDUALS. The advance in this direction is of necessity slow, but very encouraging. Here are a few statistics of mortality from preventable disease for series of years, which give positive evidence of a diminution of the rate. They are taken from the reports of the Commissioner of Statistics of the State.

SCARLATINA

for thirteen years shows an average diminution of the per cent. of deaths to total deaths from all causes. Taken in groups of three years each: 1871-73, average is 5.25; 1874-76, 4.45; 1877-79 is 3.02; 1880-83 is 3.10; and the per cent. of cases to total population has diminished in much greater proportion. Taking the years of census, the per cent. of deaths by this disease is to the total population for 1870, .054%; 1875, .044%; 1880, .019%.

TYPHOID FEVER.

Beginning in 1871 with 8.89% of total death, the percentage has almost regularly decreased till, in 1883, it was but 3.19%. In 1881-82, because of a sharp epidemic prevalence in one locality, the percentage for the whole State was raised to 6.5%, but it was epidemic no where else, and the general average for the State has been generally decreasing to date.

The following figures compare Minnesota's vital statistics with that of Massachusetts:

Massachusetts for 1880:

Births, 24.80 to 1,000 of population.

Deaths, 19.79 " " " "

Minnesota for 1879:

Births, 30.06 to 1,000 of population.

Deaths, 11.24 " " " "

And for 1880:

Births, 36.3 to 1,000 of population.

Deaths, 13.2 " " " "

The Massachusetts record for 1880 indicates one child born to every 40 persons, and one death to every 50 living, and the Minnesota record for 1879, indicates 1 child born to every 33 persons, and one death to every 89 living. The natural increase of the Massachusetts population for 1880, is 5.01 to 1,000 population, and that of Minnesota for 1879, is 18.82 to 1,000 of population.

In Minnesota for seven years, the per cent, of births to nationality were: American parents, 24.99; foreign parents, 63.28; one parent foreign, 9.52. As is to be expected the percentage of births, both parents American, is increasing. In 1882 they were 28.28% of total.

The average of deaths under two years, for seven years, ('71-77,) was 39.73 per cent.; under five years, 44.4 per cent. For 1883 the percentage of the first was 32.67, the latter was 38.62.

DIPHTHERIA is peculiarly prone to sharp local outbreaks, so that it has at no time a widespread diffusion and cannot be averaged. It is still a leading cause of mortality under 15 years of age among our population, but the belief, now thoroughly established of its very infectious character, is increasing the popular demand for more stringent enforcement of seclusion, disinfection and other sanitary measures for its control.

The prevailing diseases are still largely affected by the peculiarities of our civilization, which are first, new and

overcrowded cities, in which sanitary measures, water supply and sewerage have not yet caught up with a phenomenal growth; secondly, a portion of our agricultural population, especially newcomers, are illy supplied with roomy and well-built houses. These are serious troubles, but are disappearing under the sturdy and healthful energy which is rapidly making Minnesota a great commonwealth of happy homes. Our foreign population are thrifty and home-loving and the American-born are not far behind, so that many of our sanitary difficulties are after all but temporary, and perhaps to some extent more apparent than real, because when we come to compare our lot with other western States the conclusion is inevitable that it is a happy one, which education and culture, love of the home, the school and the church, (for all which ample provision is made,) will rapidly develop into a mighty power in the future of our common country.

THE PHYSICAL DEVELOPMENT OF THE YOUTH OF MINNESOTA AS COMPARED WITH OTHER STATES.

For several years the Secretary of the State Board of Health has collected data bearing on this matter, as aids to the solutions of questions of the relations of nationality, mode of life, climate, country and city life to the health and diseases of the youth of both sexes. The schools offered the best field for systematic work. The data drawn from the above and other sources will be found in appendix C.

Comparing the college men, the average of age is one year greater at Amherst and the mean chest girth is three inches greater; the last because of the systematic gymnastic training of the Amherst students; the Minnesota (University) students average taller and heavier; the majority are from the farming class, but all classes and every leading nationality are represented in every grade of our school-going population. Comparing the volunteer soldiers of Minnesota with those of other States and of different nationalities, the first were younger, taller, and had greater chest girth.

APPENDIX A.

RED RIVER VALLEY.

WELLS.

First line of figures—Parts per 100,000.

Second line of figures—Grains per American gallon.

No. of Specimens	Total Solids.	Volatile & Organic Matter.	Free Ammonia.	Alb. Ammonia	Chlorin	Oxidizable Matter.	Remarks.
12	178.11	36.8*	.076†	.022†	54 36		Largely volatile Chlorides. †2 specimens.
	104.5	21.5	.044	.0128			

ARTESIAN WELLS.

6	61.85 36.129	3.89 2.272			5.7 3.329		In vicinity of Moorhead.
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RIVERS.

Tributaries to Red River of the North.

3	39.06	11.8			17.6		
	22.82	6.906			10.29		

RED RIVER.

2	24.55	5.75	.006	.012	.375		At Moorhead.
	14.31	3.35	.0034	.007	.218		

LAKES.

1	112.0	18.0	.040	.008	8.		Big Stone Lake.
	65.49	10.67	.023	.004	.467		

NORTH-EAST SECTION—DULUTH AND VICINITY.

WELLS.

First line of figures, parts per 100,000.

Second line of figures, grains per American gallon.

No. of Specimens.	Total Solids.	Volatile Matter.	Free Ammonia	Alb. Ammonia	Chlorine.	Remarks.
1	36 0	10.0	.049	.093	1.0	
	21.02	5.84	.028	.057	.58	

LAKES.

1	15.2	4.4	.0008	.0024	.2	Lake Superior at Duluth.
	8.	2.57	.0004	.0012	.1167	

SPRINGS.

2	26.4	6.8	.0133	.0163	2.05	1 in Duluth 1 in Cloquet.
	15.44	3.99	.0077	.0095	1.156	

RIVERS.

1	20.00	10.0	.021	.020	1.0	†Snake river at Pine City.
	11.68	5.84	.0122	.0116	.584	

MINNESOTA AND MISSISSIPPI RIVER VALLEY REGIONS.

WELLS.

Figures of upper row, parts per 100,000.

“ lower “ grains per American gallon.

No. of Specimens.	Total Solids	Volatile Matter.	Free N H 3.	Alb. N H 3.	Chlorine.	Oxidisable Matter.	Remarks.
16	*61.22	*19.39	.0054	.0065	1.48		*6 wells from a limited area in Red Wing, containing large total solids, raised this average.
	35.761	11.326	.0032	.0038	.865		
30	53.27	12.9			1.35	†.0865	† 7 Specimens.
	31.117	7.535			.789	†.0505	
25—calling six specimens in above 30 1 spec.	44.44 25.959	9.04 5.281					The average of the above mentioned 6 specimens was called 1 spec.

RIVERS.

Mississippi River—Specimens from points between Minneapolis and Winona, inclusive.

44	21.19	*7.03	.067	.0381	.52		*41 Spec'm
	12.378	*4.107	.0391	.0223	.304		
50	21.04	‡6.5			.542	†.65	‡ 47 Spec'm † 6 Spec'm
	12.29	‡3.79			.317	†.379	

MINNESOTA RIVER.

17	36.59	9.15	.0229	.0217	.35		
	21.36	5.34	.0133	.0126	.204		

SPRINGS.

14	38.19	7.66	.0152	.0105	.987		
	22.308	4.474	.00888	.00613	.576		

LAKES.

9 from 3 Lakes.*	12.93	6.75	.0195	.0307	.23		*Lake Phalen, St. Paul supply; McCusick Lake, Stillwater supply and Spring Lake, Albert Lea.
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HIGH PRAIRIE REGION.

Figures of upper row, parts per 100,000.

Figures of lower row, grains per American gallon.

WELLS.

No. of Specimens.	Total Solids.	Volatile Matter.	Free Ammonia	Alb. Ammonia	Chlorine.	Remarks.
14	39.1	8.94	.0059	.0059	1.56	
	22.839	5.222	.0034	.0034	.911	

RIVERS.

2	39.6	9.05	.0037	.617	.325	At Owatonna.
	23.114	5.28	.0022	.010	.1897	

LAKES.

1	26.4	8.0	.005	.041	.18	Spring Lake Albert Lea
	15.41	4.669	.0029	.0239	.105	

SPRINGS.

3	38.07	8.2	.0135	.06717	.35	Near Owatonna.
	22.22	4.78	.0079	.0041	2043	

COMPARISON OF WATER SUPPLY OF SEVERAL CITIES.

Parts per 100,000.

		Total solids	Vol. Mat.	By whom analyzed.		
New York Cy..	Croton, 3 mos. '68,	7.63	1.97	Prof. Chandler.		
" " "	" " 13 wks. '67,	7.84	1.12	" "		
Brooklyn.....	Ridgewood, 3 mos. '63,	5.34	.83	" "		
Boston.....	Cochituate,	5.34	1.22	" E. N. Horsford		
Philadelphia...	Fairmount, Schuylkill,	6.01	2.06	" "		
" " "	Delevan,	6.05	1.08	" H. Wartz.		
Albany.....	Hydrant,	18.48	3.96	" Horsford.		
Troy.....	"	12.74	2.30	" W. Elderhorst.		
Utica.....	"	11.07	1.64	" Chandler,		
Syracuse.....	New Reservoir,	23.89	3.08	" "		
Cleveland.....	Lake Erie,	10.75	2.62	" J. L. Cassels.		
Chicago.....	Lake Michigan,	11.44	1.81	" J. V. Z. Blanky.		
Rochester	Genessee River,	22.74	2.12	" Chandler.		
Schenectady...	State St. Well,	84.38	4.0	" "		
Newark.....	Passaic River,	12.75	4.9	" Horsford.		
Jersey City	" "	12.75	4.9	" "		
Hoboken.....	" "	12.75	4.9	" "		
Hudson City...	" "	12.75	4.9	" "		
Trenton.....	" "	12.75	4.9	" "		
				Free Ammo.	Alb. Ammo.	Chlo- rine.
St. Paul, Minn.	Lake Phalen,.....	12.68	5.0	.0226	.0374	.21

COMPARISON OF RIVER WATERS.

Figures in first line, grains per American gallon.

Figures in second line, parts per 100,000.

	I.	II.	III.	IV.	V.	VI.
	Total solids	Vol. Mat.	Free NH ₃	Alb. NH ₃	Chl.	Oxy-gen.
Merrimack River, Mass. No. 147.....	2.56 4.400	.93 1.60	.0023 .004	.007 .0120	.12 .2	Nichols—Rivers of Massachusetts.
Merrimack aver. 11 samp, above Lowell.	2.39 4.10	1.01 1.73	.0027 .0047	.0066 .0114	.08 .14	
Merrimack aver. 11 samp. below Lawrence.....	2.59 4.43	1.05 1.79	.0018 .0031	.0074 .0127	.11 .18	
Blackstone river No. 51. Nichols p. 26..	3.81 6.52	1.38 2.36	.004 .0068	.010 .173	.29 .50	
Charles river No. 106.....	4.27 7.32	2.29 3.92	.0033 .0057	.0215 .0368	.15 .26	
Sudbury & Concord rivers. No. 161.	2.99	1.33	.0031	.0132	.18	
Assabet at Concord.....	5.12	2.28	.0053	.0227	.30	
Sudbury & Concord rivers. No. 112	3.85	1.70	.0047	.0175	.14	
Nichols p. 38.....	6.60	2.92	.0081	.030	.24	
Headwaters of Nashua river, Clinton....	4.72	2.00	.0088	.0179	.16	
Croton River, New York Cy., supply average 36 samples analyzed in 1869.....	4.78 8.20	.67 1.15				.0627 .1074
Schuylkill—at Philadelphia.....	6.01	2.06				
Hudson (?) Albany supply.....	18.4	3.96				
Genessee river, Rochester supply.....	22.74	2.12				
Passaic River, supply of Newark, Jersey City, Hoboken, etc.....	12.75	4.9				
Connecticut River, opposite Springfield, average two samples.....	6.20	1.66	.0085	.0132	.09	.393
Mississippi river in Minnesota, average thirty-four samples.....	12.21 20.92	4.25 7.29	.049 .0848	.0198 .0339	.232 .398	
Minnesota river, average of seventeen specimens.....	21.36 36.59	5.34 9.15	.0133 .0229	.0126 .0217	.204 .35	
Various rivers of Minnesota, average of fourteen specimens from ten rivers.....	14.60 25.0	4.50 7.84	.0091 .0155	.0106 .0181	.310 .53	

COMPARISON OF WELL WATERS.

SECOND ANNUAL REPORT, STATE BOARD, NEW YORK, (P. 430.)

Top lines of figures, grains per Am. gallon. Lower lines of figures, parts per 100,000.

	Total Solids.	Volatile Matter.	Free N H 3	Alb. N H 3	Chlorine.	Oxyg. absorbed in 3 hrs.	
Rome, No. 1.....	14.230 24.40	.875 1.50	.0002 .0004	None None	.511 .877	.0031 .0054	(good).....
Rome, No. 3.....	15.746 27.00	.991 1.70	None None	.0004 .0006	.577 1.333	.0010 .0016	(good).....
Watertown, No. 3.....	21.578 37.40	Trace Trace	.0012 .002	.0029 .005	5.42 9.294	.0149 .0255	(good).....
Southampton, No. 10.....	5.842 9.40	1.225 2.100	.0001 .0002	.0013 .0022	.920 1.578	.0005 .0008	(good).....
Batavia, No. 1.....	23.939 41.10	2.507 4.30	.0005 .0008	.0004 .0006	.123 .210	None None	(good).....
West Hampton, No. 2.....	12.072 20.70	3.907 6.70	.0009 .0015	.0047 .008	1.340 2.297	.0030 .109	(good).....
Cortland village, No. 1.....	13.063 22.40	1.633 2.80	None None	.00029 .0005	.123 .210	.000 .0000	(good).....
Croton Falls, No. 1.....	6.122 10.50	Trace Trace	.0023 .0040	.0029 .0050	.351 .602	.0121 .0210	(good).....

SECOND ANNUAL REPORT, STATE BOARD, NEW YORK, (P. 101.)

Geneva, No. 139.....	37.80	.....	.002	.003	.25	.....	(good).....
Average of 33 wells of Minnesota.....	22.39 38.38	5.47 9.38	.0042 .0072	.0045 .0077	.841 1.44	.....	.....

APPENDIX B.

RED WING WATER WORKS.

Red Wing, Minnesota, is situated on the right bank of the Mississippi river, forty miles below St. Paul, the capital of the State, in latitude $44^{\circ} 33'$ north, and longitude $92^{\circ} 44'$ west of Greenwich.

Water-works were built for the city by the Northwestern Water and Gas Supply Company, of Minneapolis, Minnesota, in the fall of 1883 and the summer of 1884, after plans drawn by H. H. Harrison, hydraulic engineer; and constructed under the direction and superintendence of H. B. Wilson, C. E., city engineer, the water supply being taken from the Mississippi river by a fourteen inch cast iron intake pipe extending 800 feet from the shore into the main channel of the river. From thence the water is conveyed by gravity to a screen-well; where, after passing through a filter well, and a pump-well, all of which are adjacent to the pump-house, the water is pumped by two compound duplex Blake pumps of twenty inch steam cylinders by twelve in water cylinders, by twenty-four inch stroke, (20-x12x24); the pumps being of the same dimensions and set on the same foundation, and arranged so as to work independent or together. The water is pumped to a reservoir of one million gallons capacity, situated on Sorin bluff, about one mile distance from the pump house. The elevation of the reservoir is 275 feet above the river. The reservoir is circular, eighty feet in diameter, and thirty feet in depth, and covered with a conical roof.

The distribution is by six and one-half ($6\frac{1}{2}$) miles of cast-iron pipe of 14, 12, 8, 6 and 4 inches in diameter, with fifty (50) fire hydrants, and thirty-five street gate valves.

The works having just been completed, the laying of service pipe has only just begun. The works have cost \$80,400.

The population of Red Wing is 8000. Red Wing was incorporated as a city May 4th, 1857.

ST. PAUL WATER WORKS.

DESCRIPTION OF WATER SUPPLY.

St. Paul derives her water supply from a system of lakes which lie to the north of the city and at a sufficient elevation to give a gravity supply to nearly all of the business portions and a considerable area of the resident districts. Notwithstanding the fact that the Mississippi river flows through the city and offers an inexhaustible supply, the superior advantages of the present system are obvious on careful investigation.

The topography of the city, rising as it does from the river in a succession of plateaux, until the finest of the resident portion lies at an elevation of from 230 to 240 feet above low water in the river presents difficulties which would require extensive and costly plants to overcome, if the river were taken as a source of supply. On the other hand Minnesota, as the name indicates, is noted for the number and beauty of her lakes and purity of the water, and St. Paul, in deriving her water supply from these lakes, avoids the troubles incident to high and low water in the river, contaminations from sewerage, sawdust and other impurities held in suspension during the spring freshets, while the lift on the pumps necessary to supply the portions of the city not reached by gravity is reduced about 180 feet.

Water was first introduced into St. Paul during the year 1869, by virtue of a charter granted by the legislature in 1857. The works were built and owned by a private corporation, of which Mr. C. D. Gilfillan was president, and under whose superintendence the works were constructed. The immediate source of supply was Lake Phalen, distant about two and one half miles from the city distribution, and the nearest of the system of lakes which formed the base of supply. The water was first brought to the city by gravity through a sixteen-inch cement pipe. In 1879, two-foot vitrified clay pipes were laid from the lake for a distance of 6,500 feet and connected with the other, each having separate gate chambers at the lake. The elevation of Phalen is 166 feet above the river; the territory supplied was therefore confined to the lower plateau.

The following are the details of the distribution system under the old water company:—

Twenty-four inch vitrified clay pipe.....	6,500 feet
Twenty-four inch cast-iron pipe.....	500 "
Sixteen inch cement pipe.....	7,335 "
Sixteen inch cement and wrought-iron pipe	15,735 "
Sixteen inch cast-iron pipe.....	60 "
Twelve inch cement and wrought-iron pipe.....	3,180 "
Twelve inch cast-iron pipe.....	460 "
Six inch cast-iron pipe.....	37,513 "
Four inch cast-iron pipe.....	18,835 "
Six inch cement and wrought-iron pipe.....	18,297 "
Four-inch cement and wrought-iron pipe.....	14,468 "

Hydrants, 188; water meters, 129; service pipe, 1,817.

The company also secured valuable rights of flowage, and opened canals and built gates and sluiceways to control the waters of the lakes above, forming large impounding reservoirs.

Under their charter, the city had the right at stated intervals to purchase the works.

During the year 1881 the rapid growth of the city and the great number of fine residences built on the elevated plateaux, particularly in the St. Anthony Hill district, entirely beyond the reach of a gravity supply, rendered it imperative that extensions should be made commensurate with the present needs and future growth of the city, involving a large expenditure of money. The time had evidently arrived when the city should take possession of the works. A committee was appointed, consisting of H. H. Sibley, P. H. Kelly, Geo. L. Otis, J. D. Ludden and J. P. Frizell, to examine into the condition of the works as operated by the water company, investigate the various sources of supply and report a system for adoption.

After a long and careful examination and investigation by Mr. Frizell, the engineer, the committee reported in favor of the purchase of the company's works and the adoption of the lake system, with some modifications. Vadnais Lake, belonging to the same chain of lakes, situated about six miles from the city distribution, was taken as the immediate connection, and Lake Phalen and Gervais were eliminated from the system. By this means, a gain of twenty feet was made in the head, and the liability to pollution from its proximity to the city avoided.

The plan, as adopted, contemplates materially extending the lake connections, as the needs of the city demand, until Forest Lake and the Sunrise River are made tributary to the system and a supply of 40,000,000 gallons per day is obtained.

The drainage area is large, but the percentage of rainfall that can be impounded and utilized is small in proportion to that area.

The success of our system depends on utilizing these lakes as a great natural reservoir—holding back the surplus of wet seasons and heavy rains by means of dams and properly constructed sluiceways and drawing the surplus as the needs of the city require. The following table gives the area of these lakes which can be utilized. There are already connected the following lakes:—

Vandais Lake	.....	550 Acres.
Wilkinson “	.....	200 “
Deep “	.....	100 “
Long “	.....	15 “
Charley “	.....	70 “
Pleasant “	.....	730 “
Lambert “	.....	300 “
Otter “	.....	400 “
Bass “	.....	330 “

In addition, the following lakes can be tapped at any time, should emergency require:—

White Bear Lake	.....	1,913 Acres.
Bald Eagle “	.....	1,280 “
Rice’s “	.....	3,000 “
Forest “	.....	2,352 “

In 1882 the works were purchased. A board of water commissioners was appointed to carry out the plans as adopted, consisting of C. D. Gilfillan, President, Dr. C. A. Boardman, P. H. Kelly, and C. W. Griggs. Active operations were commenced July, 1883, and have been vigorously prosecuted since. The main features of the new works are briefly described as follows:—

THE CONDUIT.

The conduit commences at gate chamber, 21x32, built on piles from Vadnais Lake, 231 feet from the shore, where the depth of water insures a pure supply. It runs in a southerly direction, following the line of the marshes and the Phalen Creek valley for about two and one-fourth miles, then, cutting through the ridges that divide the Phalen creek from the Trout Brook valley, it fol-

lows along the west shore of Sandy lake, and terminates about one-quarter of a mile south of this lake, having a total length of four and one-half miles. The size of the conduit is six feet in height by five and one-half feet in width. It is built of brick and stone, laid in cement, and, with the exception of about four hundred feet, was built entirely in excavation and below the water level of the country, requiring, in construction, the constant use of large steam pumps to lay the foundation. The depth of cutting ranges from ten to thirty-five feet, and every variety of excavation from hardpan to quicksand, was encountered. In one instance only was tunnelling resorted to for a distance of 629 feet. Great difficulty was experienced in securing a good foundation. The conduit was built on piling for a length of 675 feet, but for most of the length it rested on four-inch planks laid transversely to the line of the conduit. The capacity of the conduit is estimated at 30,000,000 gallons per twenty-four hours.

The grade is one foot in 4,000. The conduit is provided with two waste weirs and one blow-off, and can be cut off in sections by means of stop planks at the waste weirs.

It terminates in a distributing chamber 40x30 feet, provided with seven gates. The water can be turned into the distributing reservoir or directly into the city main.

The pumping station is situated about 1,000 feet from the terminal chamber, and is complete in every particular. It was erected at a cost of \$31,000, is fire-proof, and is of sufficient size to meet all future requirements. The present plant consists of two pumping engines with a capacity of 1,500,000 and 3,000,000 respectively, raised 150 feet in twenty-four hours. They were constructed by E. P. Allis & Co., of Milwaukee, Wis., at a cost of \$28,000, which price includes two steel boilers of sixty horse power each. The engines are compound, condensing with a guaranteed duty of 95,000,000 foot pounds. They are vertical engines, the high and low pressure cylinders standing directly over and connecting with the pump plungers, the fly wheel being connected by a double crank shaft. For their size and capacity they are undoubtedly the most perfect and give the highest duty of any pumping engine thus far constructed.

RESERVOIRS FOR DISTRIBUTION.

The system contemplates the construction of two reservoirs. A

low service reservoir at the end of the conduit which shall contain about 40,000,000 gallons. This reservoir completed, the safety of the city is insured against any accident to the conduit, and the necessary cleaning and repairs can be made as required. Also a high service reservoir which shall contain 18,000,000 gallons. With this reservoir completed, the pressure on the mains will be uniform, and a large saving in the cost of pumping will be secured.

PIPE.

The water is conducted into the city through a 30-inch cast iron pipe for the low service. The length of this pipe to the city distribution is 10,000 feet.

On the high service, the water is forced through a 20-inch pipe to a reservoir 310 feet above the river; from this reservoir it will run by gravity through a 24-inch pipe, 12,000 feet long, to the distribution mains of the service; until the construction of the reservoirs, the high service must depend on direct pressure.

All the distribution pipes laid since the city gained possession of the works are of cast iron. The general depth at which the pipes are laid is from seven to seven and one-half feet from the surface of the ground to bottom of pipes. But little difficulty is experienced from freezing of the water in the pipes, but the hydrants give considerable trouble in extreme cold weather, requiring the constant care of a special force of men. The house connections also require care in protecting from frost, and stringent rules and careful inspection on the part of the board of water commissioners, to prevent waste on the part of consumers by leaving open faucets to prevent freezing.

A peculiar feature of our system of distribution consists in carrying the mains in tunnels in the sand-rock at a depth of twenty-five feet below the surface. The size of the tunnels is six feet high by four feet bottom width and one foot top width.

The house connections are formed by tunnelling from the main tunnel under the point where the connection is to be made and putting down a drill hole from the surface through which a pipe is carried and connected with the main. The hydrants are made through a shaft sunk from the surface.

The length of the sand-rock tunnel is about four and one-half miles. The construction is only used when the surface is covered with a solid bed of lime rock about twelve feet thick underlaid with sandrock. Open cuttings in the solid rock to the depth re-

quired to lay pipe would be very expensive. The cost of the sand-rock tunnel is about \$1.50 per lineal foot.

The total length of pipe laid up to Nov. 1st, 1884, is as follows:

Thirty-six inch pipe	18 feet.	Sixteen inch pipe	32,440 feet.
Thirty " "	16,350 "	Twelve " "	15,285 "
Twenty-four " "	18,812 "	Six " "	104,956 "
Twenty " "	10,973 "	Four " "	38,721 "

Equivalent to 45 300-5280 miles.

Number of fire hydrants (Holly).....	102
" " (Mathews).....	213
" sprinkling hydrants.....	35
Total	350

Number of gates, 422; number of meters, 150; number of house connections, 3000.

COST.

The cost of the works up to November 1st, is as follows:

Amount paid old water company.....	\$510,000 00
Cost of new extensions, including conduit, engineering, inspection, etc., distribution pipes, gates, hydrants; grading and right of way.....	953,111 00
	\$1,463,111 00
Bonded indebtedness.....	\$1,260,000 00

Under the law, the receipts, which include a frontage tax of ten cents per front foot, must pay the bonded indebtedness and running expenses.

The works and finances are run on strict business principles, and thus far the requirements of the law have been met. As the extensions are made and number of consumers increases, the revenues will be largely augmented and a sinking fund created. Twenty miles of extension are contemplated next season.

While the cost of the works has been considerable, what has been done is on a scale to meet the requirements of a half million of people. The conduit is of sufficient size to convey all the water from the drainage ground tributary to Vadnais Lake.

Extensions will be required to develop the system and utilize its resources to the fullest extent; but, while the future rapid growth of St. Paul is assured, we believe the day is far distant when the city will be obliged to look for other sources of supply.

The present board of water commissioners and officers are as follows: C. D. Gilfillan, President; John Caulfield, Secretary; L. W. Rundlett, Engineer; J. B. Overton, Superintendent; J. F. Hoyt, C. D. O'Brien, P. H. Kelly, C. W. Griggs.

L. W. RUNDLETT,

Engineer Board of Water Commissioners.

DESCRIPTION OF THE SEWER SYSTEM OF MINNEAPOLIS, MINNESOTA.

Minneapolis now contains an area of thirty and one-quarter square miles, not including the area covered by the Mississippi River and the larger lakes within the city limits. Four-fifths of this territory lies south and west, and one-fifth north and east of the Mississippi River. Such topographical surveys as have been made show a maximum elevation of land within the city limits of 246 feet above the river where it crosses the south boundary of the city. This high land is just west of Hennepin avenue and north of Franklin Avenue. Excluding the small strip of land below the Falls, known as the Flats, and that small portion known as the Bluffs, the remaining portion of the city is not marked by any very abrupt changes of surface. The difference in elevation of the surface of the water where the river crosses the north and south boundary lines of the city is about 98 feet. The surface of the water of Bassett's Creek, where it crosses the west boundary of the city is 19.83 feet higher than it is where it empties into the river. This fall of the creek, however, is not uniform, as the fall for the distance of two miles from the river, or one-half its entire length in the city, is only five and one-half feet. The elevation of the water in the larger lakes above the city datum is as follows:

Cedar Lake.....	140.08	|	Lake of the Isles.....	143.80
Lake Harriet.....	136.15	|	Lake Calhoun.....	143.57

The elevation of the street crossing of Washington and Hennepin avenues is 131 feet. The elevation of the floor of the suspension bridge is ———— and that of the river underneath the bridge, at low water, is about 84.3 feet. The lakes named are located near together in the southwestern portion of the city and afford drainage for comparatively a small portion of its area. This fact and the probability that within a few years they will be surrounded with boulevards and drives, furnishes a good reason for not allowing any contamination of their waters with sewage. The banks of the Mississippi river below the falls are high, the current is swift, so that it affords the best outlet for the sewage of the entire city than any other known. With the exception of the valley of Bassett's Creek, the geological formation of almost the remainder of the city is favorable to the construction of the sewers with good gradi-

ents above the limestone ledge which underlies the most of the city. The topography of the city is such that it can be divided into such districts as to require no large sewers, (six feet diameter being the largest as yet), and giving to them an independent outfall. This obviates the necessity of long lateral sewers, and consequently they can be smaller and less expensive and different localities be sooner reached.

LAYING OUT AND CONSTRUCTION OF THE WORK.

In laying out the work the first requirements is to provide an outfall into the swift waters below the falls. One of the obstacles met in the beginning is the fact that but three streets reach the river below the Falls, and these are unfavorable for sewage outfalls. The sewage of any proposed district is concentrated at the most available point, and there dropped into a well and thence by a tunnel is conveyed to the river. These tunnels are built in the sand rock which underlies the strata of limestone. Excepting the tunnel for the Bassett's Creek district, these tunnels are $6\frac{1}{2}$ feet wide, and $6\frac{1}{2}$ feet high at the centers, built in the form shown on the map. Their sides are made of rubble limestone, the bottom of heavy limestone paving stone, 8 inches deep, well grouted, and the arches of concrete. The first tunnel built was built circular, of brick.

The wells are eight feet in diameter at the junction of the sewer, five feet in diameter next to the ledge, and two feet in diameter at the surface of the street. The hole through the ledge is four feet in diameter. The well below the ledge is twelve feet across and extends below the bottom of the tunnel from six to twelve feet, and is lined with heavy limestone, and all the masonry of the tunnels and wells is laid in cement mortar. The tunnels constructed are as follows, named in the order of their construction:

Eighth avenue S., from the river to Washington avenue,	868 ft long
Fourth street from the river to 21st avenue S.....	940 "
Tenth avenue S. E., from the river to 2d street.....	470 "
Eleventh avenue S., from the river to midway between 1st street and 2d street	650 "

These tunnels afford an outlet for the sewage and storm waters for an area of more than 2,000 acres. The ordinary minimum velocity of flow in the sewers is three feet per second.

The chief avenues are 100 feet wide. The remainder of the streets in the business portion of the city are eighty feet wide, and

the sewers are laid at an average depth of sixteen feet. In some localities, before reaching this depth, clay dams are met, which hold back large quantities of water, which necessitates laying a sub-drain pipe under the sewer, or pumping to remove the water which comes into the trenches.

The sizes of the sewers are determined according to the Adams formula, calculated for a rainfall of one inch per hour, one-half of the water reaching the sewers in the same time.

In the northeastern portion of the city it is proposed to construct an overflow across the district, so as to discharge the storm waters into the river above the falls, thus allowing the sewers to be built much smaller in the lower districts.

The construction of sewers in this city was commenced in the the spring of 1871, and previous to April 1, 1882, but 2.58 miles had been built. In 1882, 2.87 miles were built, exclusive of tunnels. In the year 1883, 6.05 miles were built, and during the past season, 6.25 miles have been built, making a total of 17.5 miles of sewer and tunnels in use at this time. There is ordered to be built next season over six miles more. Manholes are built about 125 feet apart. Arrangements for flushing will be put in at the upper end of such of the sewers as may be necessary to secure proper cleansing. The covers of the manholes are perforated and ventilation is in the middle of the street. The inlets are at corners of the blocks, and in order to guard against the drain-pipes being clogged with ice in our cold winters, the drain pipes discharge into the sewers at the manholes without crooked traps. This arrangement permits readiness of access for the removal of stoppages.

BASSETT'S CREEK.

The great problem to be solved is in connection with the draining of all that district which is tributary to the creek. Its watershed is about 9,000 acres. Immediately after entering into the city, it spreads out over a large area, which has the appearance of once having been a lake, which has gradually been filled up by the washings of the creek and the bluffs in the immediate vicinity. The Mississippi river, in its ordinary stages of high water, sets back over the most of this low district and until near the western boundary of the city, a distance of two miles. It has been an important question, "How to discharge the vast amount of sewage and the storm-waters of the district into the river, and secure the best san-

itary conditions to the population in the vicinity of the creek, together with proper economy in construction, and efficiency of operation." Direct discharge into the river above the falls, following the shortest lines, has been strongly advocated as being the cheapest, and the soonest brought into operation. Another proposition has been, to straighten the creek, discharge the sewers into it, and pass the whole into a tunnel and thence into the river below the falls. These plans, and others, have been put aside for the one now adopted and being constructed.

This plan comprises, first, a tunnel seven and one-half feet in diameter and 7,000 feet long, built in the sand-rock strata, under the limestone ledge, from the river at the foot of 8th Avenue S. to to the intersection of 5th Street with 6th Avenue N., distant about 800 feet from the creek. The tunnel will be about 50 feet lower than the creek. This, together with the fact that during the last quarter of a mile of its length the tunnel will have to be constructed in wet sand, has rendered it unadvisable to approach any nearer to the creek with the tunnel. At the end of the tunnel a well is to be constructed, into which the sewers from various directions will discharge their contents. This well will be constructed so that the tunnel and the various sewers may be approached without trouble from the falling contents of any of the sewers. From the well a large intercepting sewer, seven feet in diameter, will be built along the streets near the creek, crossing it but twice, into which smaller intercepting sewers will enter, at such points as the topography of the district may require. These intercepting sewers will be from five feet to seven feet below the bed of the creek, thus permitting the smaller lateral intercepting sewers to pass under the creek at such places as may be necessary. As soon as the intercepting sewer is built to the creek, the main sewers of North Minneapolis may be connected with it, providing at the same time for such storm-water overflows into the river or creek as will be best. By locating the main sewers so that the storm-waters can be discharged frequently, the sizes of the laterals may be diminished, and so lessening the cost of the system. The district of Northeast Minneapolis will be treated in a similar manner; the tunnel, however, will be about two miles long, with three points of concentration and inlets into it.

By carrying out this plan, the contamination of the water in the river and creek is avoided, or at least such a possibility is reduced to a minimum.

APPENDIX C.

TABLE GIVING SPECIFIED MEASUREMENTS OF MINNESOTA STUDENTS IN COLLEGES, NORMAL SCHOOLS, HIGH SCHOOLS AND COMMON SCHOOLS.

The statistics of University, Normal Schools, High Schools and Common Schools give four series of observations of four periods of age, under 21 years, of our population, and of the differences at those ages between the sexes.

	Age in years.	Height in inches.	Weight in pounds.	Girth of chest in inches.	Chest expansion in inches.	Chest capacity in cubic inches.
In the University of Minnesota the average of two years.....	20.75	65.61	142.75	33.06	3.84	243.18
1. In Amherst College, average of 8 years	21.72	67.81	139.49	34.14		
2. Average of about 10,000 of different nationalities and colored men of the volunteer force of U. S. A.....	27.08	66.61	137.5	32.82	3.23	
2. Average of about 4,000 Minnesota Volunteers of U. S. army	18.45	68.37		34.02	2.79	
Normal Schools (males) of Minnesota.....	18.95	67.44	141.91	34.0	3.20	
High Schools of Minnesota.....	16.26	65.40	125.50	33.23	2.28	
Naval Academy at Annapolis.....	15.43	63.23	101.98	29.66	2.43	
Common schools of Minnesota (males).....	11.57	55.50	87.15	27.68	2.41	
MEANS OF FEMALES.						
University of Minnesota.....	21.06	64.77	122.45	30.99	3.48	
Normal Schools of Minnesota.....	17.15	63.30	123.55	32.83	2.40	
High Schools of Minnesota.....	16.25	62.88	113.89	32.22	1.90	
Common Schools of Minnesota.....	10.59	51.00	86.3	26.4	2.00	

1. Dr. Hitchcock's Report.
2. Provost Marshal General's Report.

